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SEVENTIETH

ANNUAL REPORT

OF THE

DIRECTOR

OF

THE ASTRONOMICAL OBSERVATORY

OF

HARVARD COLLEGE

FOR THE YEAR ENDING SEPTEMBER 30, 1915

BY

EDWARD C. PICKERING

CAMBRIDGE, MASS.
PUBLISHED BY THE UNIVERSITY
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THE OBSERVATORY

To the President of the University: —

Sir, — During the last year, the Observatory has lost, by the death of Anna Palmer Draper, its most generous benefactor. It rarely happens that a woman maintains for many years a great scientific enterprise, and by monthly subscriptions shows her unfailing interest in it. Mrs. Draper for nearly thirty years supported the Henry Draper Memorial, and by her will placed it upon a permanent foundation. Its object is to develop the great achievement of Dr. Draper, who first photographed the lines in the spectrum of a star. In early life, Mrs. Draper accompanied and assisted her husband whenever he went to his Observatory. After his death she showed the greatest interest in the progress of the work here, by frequent visits to Cambridge and personal inspection of the results.

Most fortunately, the meetings two years ago at Bonn and Hamburg secured international acceptance of the solution of two of the most important problems in Astronomy, the adoption of a system of classification of stellar spectra, and the basis of the scale of photographic magnitudes. In each case, nearly all the great nations of Europe were represented on the Committee, and, after a most friendly discussion, the conclusions were practically unanimous. The systems adopted at this Observatory were accepted in both instances, and we are thus encouraged to continue the work with the assurance that they will secure universal acceptance. Investigations of great extent are now in progress in each of these directions, and the speed with which they can be completed will depend upon the assistance rendered in addition to the funds of the Observatory. The gifts of Mr. George R. Agassiz and of Mr. Charles S. Hinchman have been repeated this year, and form an excellent illustration of the efficient use that can now be made of increased means. The first of these gifts has provided for two additional assistants, which greatly expedites the preparation of the New Draper Catalogue. The second provides a Maria Mitchell Fellowship, and by means of it an important investigation on the variable stars is now in progress.

One of the great dangers to which the Observatory is exposed is fire. A plan has been prepared by which this risk could be greatly diminished at moderate expense. The main building, which

contains the library, is of wood and is very inflammable. The Sears Tower is of brick and is now surrounded on three sides by wooden structures. At an expense estimated at nine thousand dollars, this tower could be connected by a brick wing with the building containing the collection of photographs, which is of brick. Provision would thus be made for placing the greater portion of the library in a secure position.

Henry Draper Memorial

The first step in the formation of the New Draper Catalogue is the classification of the spectra. This portion of the work is now completed. Miss Cannon has classified 72,509 spectra this year, making the total number 233,050. The entire sky from the North to the South Poles has thus been covered. Since some plates are better than others, additional photographs will be taken, if required, to classify the fainter stars and thus render the limiting magnitude as nearly as possible the same throughout. Ten new variables, twenty-seven stars having composite spectra, and five stars having peculiar spectra have been found. To render the results immediately available, in reply to requests, the classes of 8,641 spectra have been sent to fourteen astronomers in Denmark, England, France, Germany, Holland, Italy, and the United States.

Professor King has continued in charge of the photographic work in Cambridge. The total number of plates exposed was 8,924, of which 8,257 were photographs of the stars. Of these, 278, making 39,163 in all, were taken with the 8-inch Draper Telescope. The repeated photographs of the entire sky, night after night, were also continued with the Cooke and Voigtländer instruments. The systematic tests of the plates have been continued, the work extending over a total period of nineteen years. A developer has been made from paramidophenol, the active agent of rodinal, which is as efficient as the latter. The cost has thus been reduced one-half. Plates for photographing by yellow light are now stained both here and at Arequipa, with the result that they are twice as sensitive as the best commercial plates.

Boyden Department

The Arequipa Station remained under the charge of Mr. Leon Campbell until his return to Cambridge, July 13, 1915. Mr. Frank E. Hinkley took charge of the photographic work in March and of the entire station in July. As a result of persistent effort on his part, excellent photographs are now being obtained with

all the principal instruments. The Bache Telescope was sent to Cambridge in January, 1915, for repairs, after active use throughout nearly every clear evening for thirty-two years. It was returned to Arequipa in July. Eight hundred and fifty-eight photographs were taken with it, making 45,966, in all. Three hundred and fifty photographs were taken with the Bruce Telescope, making 11,405, in all. Both instruments have been provided with diffraction gratings placed over the objectives, and are now in regular use for determining the photographic magnitudes of the stars. The total number of plates taken at the Station is 2,964, the largest number for several years. The principal use of the 13-inch Boyden Telescope has been for visual observations by Mr. Campbell. Nine thousand and ninety-two photometric settings have been made, including 564 settings on the satellites of Jupiter, during ten eclipses. Nine hundred and sixty estimates of southern variables have also been made. Seismological and meteorological observations have been maintained regularly. The Lima time signals were observed for the use of the Yale Peruvian Expedition, and 1610 pyrheliometric measures on 83 days were taken at the request of the Smithsonian Institution. Good progress has been made, under the supervision of Professor Bailey, in the reduction of the meteorological observations made at several stations in Peru during the years 1896 to 1900.

The Mandeville Station has remained under the charge of Professor W. H. Pickering. Thirteen photographs have been taken with the Cooke Anastigmat lens with exposures ranging from one to twenty-eight hours. Owing to the excellent atmospheric conditions, the 11-inch Draper Telescope has been used for special visual observations. Thirty-nine measures have been made of 12 double stars whose distances range from 0″.19 to 0″.66. The average deviation of the measures of distance is ± 0″.01. They are compared with a series of ellipses of different eccentricities. A careful study has been made of changes in the surface of the Moon, of the colors of the stars and planets, and of Mars. During the last opposition, four of the series of reports have been issued, and coöperation secured with observers in other longitudes.

Blue Hill Meteorological Observatory

Continuous records with check observations of pressure, temperature, wind direction and velocity, sunshine, precipitation, and cloudiness have been maintained without interruption during the year, thus completing a series of thirty years. The daily observa-

tions and yearly summaries for 1911, 1912, 1913, and 1914 have been published in H. A. **73**, Part **2**, thus practically bringing the observations up to date. An effort will be made to put in type certain tabular matter without waiting till the close of the year, so that Part **3**, containing the data for 1915 and the discussion of the thirty year data, may be issued early in 1916. Prompt publication of meteorological records is a matter of importance and has been the subject of discussion in International Conferences.

This Observatory was the first American institution to adopt the new units and to abandon, as far as possible, arbitrary and unscientific measures. It has insisted upon the use of the megabar for an absolute atmosphere instead of the bar as used by certain European meteorologists of prominence. The value formerly expressed as a millibar becomes, in the new notation, a kilobar and brings meteorology in line with physics and chemistry in conforming with the c. g. s. units. The Director of one of the largest European Weather Services is inclined to adopt this notation, and probably in a short time its use will become general.

Special investigations on Temperature Inversions in relation to Frosts are being carried on with some work in exploring the lower levels of the atmosphere. The war in Europe has disarranged all plans for international coöperation, in connection with exploration of the high levels.

Photographic Magnitudes

The 16-inch Metcalf Telescope has now become one of the most important of the instruments mounted at Cambridge. It supplements, for the northern stars, the work on the southern stars of the 24-inch Bruce Telescope at Arequipa. Two thousand eight hundred photographs have been taken with it, making 9,307, in all. The 24-inch Reflector permits the work to be extended to still fainter stars. Four hundred and eighty-three photographs have been taken, making 1,615, in all. The 8-inch Bache Telescope has also been used, mainly in determining photographic magnitudes. Diffraction gratings have been placed in front of each of these instruments. All magnitudes can thus be reduced to the standard scale. It is very satisfactory to find that this method confirmed all the others which had been used in fixing the magnitudes of the Standard North Polar Sequence published in H. A. **71**, No. **3**. Two hundred and ten series of twelve plates each, making 550 in all, have served to transfer this scale of magnitudes to stars

in other parts of the sky. Of these, 141, or 322 in all, have been measured. About one-third of them have been taken with yellow light. The principal regions included are the 50 Harvard Standard Regions, the 252 Selected Areas of Kapteyn, the 204 Standard Regions for the International Chart of the Sky, and numerous variables, clusters, and other objects of special interest. For many of these regions photo-visual magnitudes have also been determined from photographs taken with yellow light. All of this work has made excellent progress under the supervision of Miss Leavitt. A simple system has thus been evolved by which the photographic and photo-visual magnitudes of stars in all parts of the sky can be determined on a scale which is the same for all. Among the important services rendered by Mr. Metcalf to the Observatory is the construction of a triplet having an aperture of ten inches, making it, with one exception, the largest instrument of its kind in the world. A large part of the grinding, polishing, and testing has been done here under the supervision of Mr. Metcalf.

Variable Stars

By the effective supervision of Mr. W. T. Olcott, excellent progress has been made in the study of variable stars of long period. Seventeen thousand five hundred and fifty-two observations have been made or received here from the 33 observers named below: —

Mr. H. L. Baldwin, 69; Mr. H. C. Bancroft, Jr., 805; Mrs. H. C. Bancroft, Jr., 9; Mr. L. Barbour, 298; Mr. A. T. Bolfing, 108; Mr. T. C. H. Bouton, 679; Mr. A. B. Burbeck, 684; Mr. L. Campbell, 1200; Mr. A. P. C. Craig, 63; Mr. H. O. Eaton, 413; Professor G. L. Harrell, 19; Mr. F. H. Hay, 501; Mr. W. Herriott, 74; Mr. W. P. Hoge, 23; Mr. S. C. Hunter, 160; Mr. S. H. Huntington, 52; Mr. M. W. Jacobs, Jr., 37; Mr. J. B. Lacchini, 847; Mr. F. C. Leonard, 46; Mr. C. B. Lindsley, 845; Mr. O. Mach, 368; Mr. C. Y. McAteer, 1343; Mr. C. S. Mundt, 209; Dr. P. W. Merrill, 208; Mr. G. F. Nolte, 6; Mr. W. T. Olcott, 815; Mr. D. B. Pickering, 564; Mr. C. F. Richter, 5578; Mr. F. H. Spinney, 342; Miss H. M. Swartz, 185; Mr. H. W. Vrooman, 400; Miss I. E. Woods, 275; and Professor A. S. Young, 327.

The discussion of the variables in the cluster Messier 5, by Professor Bailey, is now nearly ready for publication.

Miscellaneous

Phillips Library. — The Library of the Observatory has been increased by 408 volumes and 2,360 pamphlets. As 1,961 of the latter have been bound in volumes, the present extent of the library is 14,902 volumes and 35,989 pamphlets.

Telegraphic Announcements. — In September, 1914, the Centralstelle was removed from Kiel to Copenhagen. Telegraphic messages could thus be exchanged, but the refusal of the censors to permit cipher messages to be transmitted has greatly interfered with the efficiency of the service. Seventeen cablegrams have been sent to Copenhagen and to astronomers in North and South America, where communication has not been interrupted. It is requested, therefore, that announcements be sent here, as usual, cablegrams addressed "Observatory, Boston," and telegrams, "Harvard College Observatory, Cambridge, Mass." They will be given as wide a distribution abroad as practicable. These telegrams are sent at cost to all who wish for them.

Twenty-five bulletins have been issued, making 590 in all. They are printed promptly and not only contain all the telegraphic announcements, but much additional information sent for that purpose. They are sent without charge to all receiving the telegrams, and at a price less than cost to all others desiring them.

Publications. — During the last year, Volumes **71**, No. **3**, The North Polar Sequence; **73**, Part **2**, Blue Hill Meteorological Observatory, 1911–14; **76**, No. **2**, Color Equation of Various Star Catalogues; **76**, No. **3**, Spectra having Bright Lines; **76**, No. **4**, Globular Clusters; **76**, No. **5**, Photographic Magnitudes of Bright Southern Stars; **76**, No. **6**, Combined Out-of-Focus Results from Several Instruments; **76**, No. **7**, Photographic Determinations of the Position of the Moon; **76**, No. **8**, The Light Curve of Eros in 1914; **76**, No. **9**, Limiting Magnitudes and Uncertainty of Catalogues; **77**, Comparison with other Catalogues of the Catalogue of 8,337 Stars in the Zone $-10°$ to $-14°$; **80**, No. **1**, Index to the Harvard Annals, have been distributed. **76**, No. **10**, Photographic Magnitudes of Polar Stars obtained with the 24-inch Reflector; **80**, No. **2**, Photographic Plates showing Faint Stars; **80**, No. **3**, Illustrations in the Harvard Annals, are partly in type, or at the printer's. The set of Annals from **1** to **80** is, therefore, complete and distributed, except **71**, No. **4**; **73**, Part **3**; **76**, numbers following No. **9**; **78**, Part **2**; **79**; **80**, numbers following No. **1**. Four

circulars have been issued, whose numbers, titles, and dates are as follows: —

185. A Second Harvard Map of the Sky. November 13, 1914.
186. Observations of SZ Tauri. November 14, 1914.
187. Campbell's Comet, 1914e. January 27, 1915.
188. Color Index of S Cephei. August 30, 1915.

Various other publications by officers of the Observatory are described in the *Harvard University Gazette* each month.

EDWARD C. PICKERING, *Director.*